MAGNETORESISTIVE SENSOR

FIELD OF THE INVENTION

[0001] The invention relates to a magnetoresistive sensor comprising at least one sensor element for measuring a magnetic field, and a supporting magnet assigned to the sensor element.

BACKGROUND OF THE INVENTION

[0002] It is known to use magnetoresistive sensors as proximity sensors, motion sensors or position sensors. In the sensors, an external magnetic field is utilized, which produces a proportional voltage signal of the sensor element when the position of the object to be detected changes relative to the source of the external magnetic field. Such magnetoresistive sensors are used, for example, for detecting reference marks in crankshaft angle measurements.

[0003] The sensor elements measuring the magnetic field do not usually operate in their saturation range and are based on the principle of the anisotropic magnetoresistive effect. It is therefore known to superimpose on these sensor elements a magnetic field stabilizing the transfer characteristic, which magnetic field is usually produced by a supporting magnet assigned to the sensor element. In the case of passive, ferromagnetic objects to be detected, the magnet is further used for the purpose of providing an operating field whose change is detected under the influence of the object. The magnet and the sensor element are then in a defined fixed position relative to each other. It is known that already slight positioning tolerances between the sensor element and the magnet in the sensitive direction lead to an offset of the characteristic curve of the sensor element. This characteristic curve offset must be compensated by subsequent trimming of the magnetoresistive sensor.

OBJECT AND SUMMARY OF THE INVENTION

[0004] It is therefore an object of the invention to provide a magnetoresistive sensor which has a simple structure and does not require subsequent trimming for offset compensation.

[0005] According to the invention, this object is solved by a magnetoresistive sensor as defined in claim **1**. Since the magnet has structures, preferably on its surface assigned to the at least one sensor element, which structures lead to a perpendicular guidance of magnetic flux lines in the sensitive range, it is advantageously achieved that only minimal magnetic fields, which might lead to an offset of the characteristic curve of the sensor element, occur in the positioning plane between the sensor element and the magnet in the sensitive direction. When the supporting magnet according to the invention is used, subsequent trimming of the magnetoresistive sensor is thus not necessary.

[0006] In a preferred embodiment of the invention, the structures are formed in such a way that a perpendicular guidance of the magnetic flux lines of the magnet with respect to the positioning plane is maintained in the sensor area. As a result, minimal magnetic fields in the sensitive direction of the positioning plane can be achieved in an optimal manner.

[0007] In a preferred embodiment of the invention, the surface structures are constituted by trough-shaped indentations of the magnet, in which the at least one sensor element is arranged. In accordance with preferred embodiments, the trough-shaped indentations are constituted by plane surfaces or concave surfaces with respect to the positioning plane. It is achieved in a simple manner by such an embodiment that magnetic fields in the positioning plane can be optimally minimized in the positioning area of the sensor elements.

[0008] In addition to the fact that magnetic trimming of the magnetoresistive sensor can be dispensed with, anisotropic magnetic materials may be used for the magnets in the embodiments according to the invention. These materials are distinguished by their high magnetic long-time stability. Finally, the measuring accuracy of the magnetoresistive sensor is enhanced because of the absence of trimming and thereby a possible trimming error.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

[0010] In the drawings:

[0011] **FIGS. 1 and 2** show a magnetoresistive sensor in a diagrammatic plan view and side elevation;

[0012] FIGS. **3** to **6** are different diagrammatic perspective views of sensors according to the invention, and

[0013] **FIG. 7** shows a magnetic field distribution of the supporting magnet according to the invention, shown in **FIG. 3**.

DESCRIPTION OF EMBODIMENTS

[0014] **FIGS. 1 and 2** show a magnetoresistive sensor **100**. The sensor **100** comprises at least a sensor element **12** which is assigned to a magnet **14**. Sensor element **12** and magnet **14** are flexibly connected together in an appropriate manner, for example, glued to each other. A sensor element **12** is herein understood to mean a sensor chip which may comprise a plurality of magnetoresistive ranges (resistances) in a bridge circuit configuration. Furthermore, the sensor chip may comprise integrated electronic components for evaluating the sensor signals.

[0015] For the purpose of clarity, a system of co-ordinates is incorporated in the Figures. It can be seen from **FIGS. 1 and 2** that an x/y plane extends parallel to a surface **16** of the magnet **14**. The surface **16** simultaneously constitutes the positioning plane for the sensor element **12** on the supporting magnet **14**. An x/z plane subtends perpendicularly to the surface **16**, in which the magnetization vector of the magnet is situated. An y/z plane also subtends perpendicularly to the surface **16**, but is 90° rotated with respect to the x/z plane.

[0016] The sensitive direction of the sensor **100** is the y direction. This means that, in the case of an approach to an external magnetic field, for example, by a reference magnet during measurement of a crankshaft angle, this magnet is moved in the y direction past the sensor **100**. The approach and the instantaneous position of the reference magnet and thus, for example, the position of the crankshaft can thereby be detected.

[0017] FIGS. **3** to **6** show four different variants of the magnet **14**. As is shown in these Figures, the surface **16** has